Upper Ocean Mixing, Coastal Mixing, LIWI, & CM AASERT

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LONG-TERM GOAL

My long-term goals are to identify and quantify the major mixing processes in the upper ocean and to relate them to the larger-scale processes producing the mixing as quantitatively as possible. When successful, this will take the form of parameterizations that can be used in numerical models.

OBJECTIVES

My scientific objectives are to measure mixing directly with microstructure sensors and to relate these measurements to the larger scales producing the mixing in such a way that the results can be compared with either the large-scale changes resulting from the mixing or with theoretical predictions of mixing rates. My technological objectives are to develop instruments and sensors to measure the major mixing parameters.

APPROACH

Because a first-order understanding of mixing in the open ocean is rapidly being developed, our approach has shifted to obtaining a similar understanding of mixing near coasts and in estuaries. Because dissipation rates are higher in these waters, we have also shifted our technological developments to improve the spatial resolution of microstructure sensors and to adapt open-ocean measurements of finescale velocity to shallow water.

WORK COMPLETED

Emin Ozsoy, our Turkish colleague, visited us in September 1998 to complete the first paper submitted about our 1994 observations in the Bosphorus. That paper was submitted (Gregg et al., 1998), and we

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are writing a second for submission late this year. We presented some of these results at a Symposium honoring Konostantin Fedorov in St. Petersburg in May 1998 and they are being published (Ozsoy et al, 1998).

Ren-Chieh Lien is the senior author on a draft manuscript analyzing observations of elevated shear and turbulence in an internal tidal beam observed on the continental Slope near Monterey, California in 1997 as part of the Littoral Internal Waves Initiative (LIWI).

All of the data from both cruises of the Coastal Mixing and Optics program have been processed and presented at the 1998 Ocean Sciences Meeting and the CMO workshop in Colorado in September 1998. Cd roms have been given to several of the CMO PIs and Jennifer MacKinnon is working on the analysis for her Ph.D. dissertation.

Jody Klymak has analyzed the three-dimensional structure of flow over the Knight Inlet sill for his Ph.D. dissertation and is now considering the dynamical implications of the results.

RESULTS

We demonstrated that at some times flow in the Bosphorus is strongly quasi-steady. During those times it makes a good natural laboratory for testing steady hydraulic theory. We were also able to estimate the surface slope along the strait from the observed mean density and velocity fields. As seen in Fig. 1, the surface slopes most steeply where the zero-flow surface dips, which is in the primary contraction of the strait.

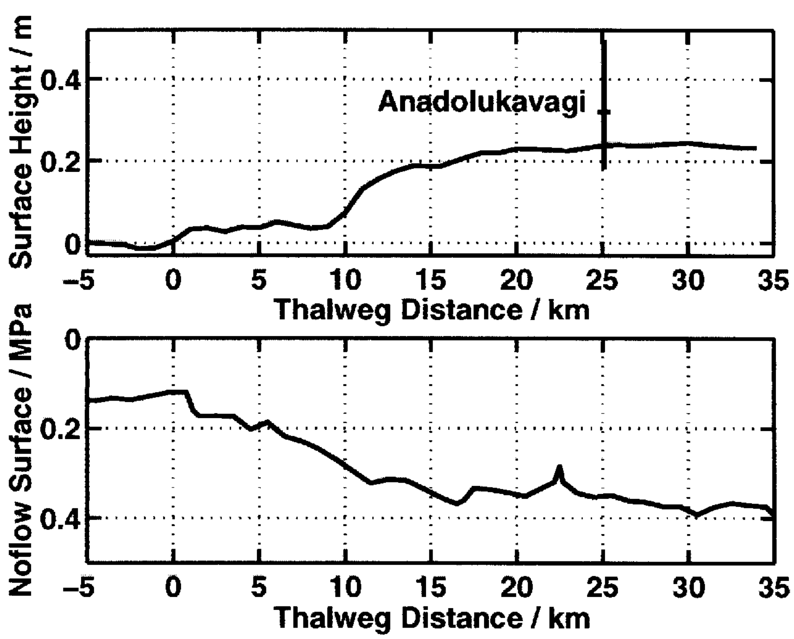

Fig. 1. Observed pressure of noflow (lower) and surface (upper). The vertical line shows the range and mean sea level difference along the Bosphorus. The primary drop in surface height occurs between 10 and 15 km from the southern entrance, where the strait is narrowest.

The LIWI observations give the best evidence we know of to date for mixing in a tidal beam. Microstructure measurements were taken continuously along a fan ridge for five semidiurnal tidal periods. We observed a beam of enhanced turbulence mixing emanating from the shelf-break, extending for about four km (Fig. 2). The vertical scale of the beam is about 50 m. The average turbulence dissipation rate ε within the beam is about 10^{-6} W kg^{-1}. The beam of enhanced turbulence follows the slope of characteristics of semidiurnal internal tide. Strong turbulence mixing also exists within O (100 m) off the bottom on the continental slope.

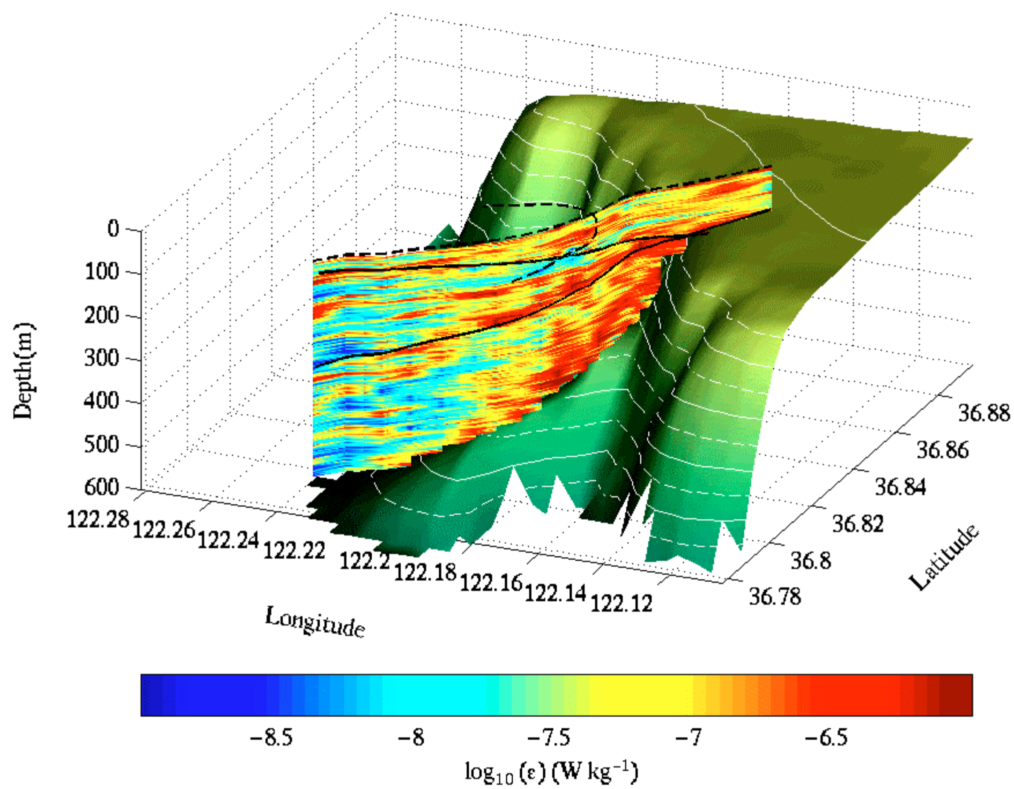

Fig. 2. Contour of ε averaged over the along-ridge sections. Two dashed lines denote the average ship tracks along and across the fan ridge. Two solid lines show the characteristics of semidiurnal internal tides.

IMPACT/APPLICATION

Demonstration of low mixing rates in the upper thermocline of the open ocean by this project during previous years is leading many modelers to examine the role of mixing in their models and to develop models with more realistic mixing.

Our demonstration of low mixing rates most of the time during CMO is leading the optical and biological investigators to change their assumptions about how optical features evolve and to examine the role of advection.

TRANSITIONS

Development of a thinistor for measuring temperature microstructure, is funded by NSF with Prof. Fumio Ohuchi, University of Washington, Dept. of Materials Science and Engineering, based on preliminary work funded by ONR.

Observations of Mixing in the Banda Sea, a project funded by NSF, will use instruments developed with ONR funding to make the first mixing measurements in Indonesian waters in October 1998.

RELATED PROJECTS

1. Internal Waves and Mixing in Monterey Canyon with Eric Kunze and Leslie Rosenfeld, funded by NSF.

2. Hawaii Ocean Mixing Experiment (HOME) proposed to NSF by many investigators.

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